GROUNDWATER BACKGROUND DOCUMENT

Parts of the data evaluation performed in the Data Summary Report (Volume 2, Appendix B of the Feasibility Study) and the Baseline Risk Assessment (Volume 3, Appendix C of the Feasibility Study) relied on screening constituent concentrations against those which may be naturally occurring (i.e., background).

Constituent concentrations in groundwater were screened against background concentrations presented in the following draft document.

The reader is cautioned that the values derived in the following draft background document are provisional and subject to significant revision.

DOE/OR/07-1857&D2
Primary Document

Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky

Volume 5. Appendix D Groundwater Background Document

Date Issued—August 2001

Prepared for the
Department of Energy
Office of Environmental Management

By
Bechtel Jacobs Company LLC
managing the

Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
Paducah, Kentucky 42001
managed by
Bechtel Jacobs Company LLC
for the
U.S. Department of Energy
under contract DE-AC05-98OR22700

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not be considered an eligible contractor for its review.

KY/EM-XXX

BACKGROUND CONCENTRATIONS OF NATURALLY OCCURRING INORGANIC CHEMICALS AND SELECTED RADIONUCLIDES IN THE REGIONAL GRAVEL AQUIFER AND MCNAIRY FORMATION AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY

AUGUST 2001

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Date Issued—August 2001

Prepared by
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Prepared for the
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under budget and reporting code EW 20

Environmental Management Activities at the
PADUCAH GASEOUS DIFFUSION PLANT
Paducah, Kentucky 42002
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BECHTEL JACOBS COMPANY LLC
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PREFACE

This report presents background concentrations for naturally occurring inorganic chemicals and selected radionuclides found in groundwater drawn from the Regional Gravel Aquifer (RGA) and the McNairy Formation at the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky. In addition, this report compares the background concentrations to human health risk-based concentrations to develop a list of screening criteria that can be used to identify significant contamination in these groundwater sources at this facility. Such screening criteria are required for Resource Conservation and Recovery Act Appendix IX and Contract Laboratory Program total analyte list inorganic chemicals and for radionuclides to ensure that remedial investigations and feasibility studies for identified areas of concern and solid waste management units at PGDP focus on those contaminants that may influence human health risk. In addition, appropriate screening criteria are needed to determine if areas currently not under investigation should be added to the list of those areas to be investigated at PGDP. These values are to be used when completing work plans and reports produced as part of the environmental restoration and waste management programs at PGDP. The work was performed under Work Breakdown Structure 1.4.12.7.1.02.04 entitled Corrective Measures for Offsite Contamination.

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FIGURES

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TABLES

ACRONYMS

bgs	below ground surface
DOE	United States Department of Energy
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
HI	hazard index
IDs	identifiers
KDEP	Kentucky Department of Environmental Protection
PGDP	Paducah Gaseous Diffusion Plant
PQL	practical quantitation limit
RBCs	risk based concentrations
RGA	Regional Gravel Aquifer
TCE	trichloroethene

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EXECUTIVE SUMMARY

This report documents the methods used to develop background concentrations of naturally occurring inorganic chemicals and selected radionuclides present in groundwater drawn from the Regional Gravel Aquifer (RGA) and the McNairy Formation at the Paducah Gaseous Diffusion Plant (PGDP) located near Paducah, Kentucky. This report also presents the background concentrations developed and compares these concentrations to human health risk-based concentrations. Subsequent to this comparison, a list of screening criteria for the naturally occurring chemicals and selected radionuclides is developed. This list is provided so that users can determine if detected concentrations of naturally occurring inorganic chemicals and selected radionuclides are present at levels that represent contamination and at levels that may present an unacceptable risk to the health of groundwater users.

All data used in the development of the background concentrations were from groundwater taken from wells not believed to be impacted by contaminant releases from PGDP. The identifiers, general location, and screen depth of the background RGA wells are:

- MW103, south of the PGDP, deep RGA–79.5 to 90 feet below ground surface (ft bgs);
- MW106, northwest of the PGDP, middle RGA–62 to 75 ft bgs;
- MW141, west northwest of the PGDP, deep RGA–79 to 80 ft bgs;
- MW142, west northwest of the PGDP, upper RGA–42.5 to 52.5 ft bgs;
- MW150, east of the PGDP, deep RGA–66 to 96 ft bgs; and
- MW199, northwest of the PGDP, upper RGA–57 to 62 ft bgs.

The identifiers, general location, and screen depth of the background McNairy Formation wells are:

- MW102, south of the PGDP, middle McNairy Formation–136 to 146 ft bgs;
- MW120, southeast of the PGDP, deep McNairy Formation–160 to 170 ft bgs;
- MW121, northwest of the PGDP, deep McNairy Formation–200 to 210 ft bgs;
- MW122, east of the PGDP, middle McNairy Formation–148 to 158 ft bgs;
- MW133, northeast of the PGDP, upper McNairy Formation–80 to 90 ft bgs;
- MW140, west northwest of the PGDP, middle McNairy Formation–138 to 148 ft bgs;

Two additional McNairy Formation wells were considered for selection as background wells. These were MW239 and MW247. These wells, which are located in the north and south well fields installed as part of the northwest plume interim remedial action, were subsequently not selected as background wells because sampling results indicated that groundwater at these locations and depths may contain a primary PGDP contaminant, trichloroethene (TCE).

In the analyses of the groundwater data from these wells, data were summarized both over all observations within group (i.e., RGA and McNairy Formation) and over wells within group. Analyses were completed in this manner to ensure that the effect of temporal correlation between samples from a single well and the impact of varying well data set sizes could be examined. It should be noted that no attempt was made to adjust the background calculations for the effect of spatial correlation. This adjustment was not attempted because a preliminary analysis indicated that the number of wells within each group was not sufficient to allow for the estimation of any spatial correlation effects. If spatial correlation does exist, then the background concentrations may be underestimated. This effect is due to underestimation of the standard deviations and errors used in the derivation of the background concentrations (see Gilbert 1987; page 35). In any case, the net effect of not considering spatial correlation is that the background concentrations are unlikely to exceed the true background concentrations.

For inorganic chemicals, background concentrations were derived for both total and filtered samples over all observations within group and over wells within group after evaluating and correcting the data sets. Important reasons for correcting the data sets are listed below.

- Value in the data set was a nondetect, but the value was greater than the greatest detected concentration. In this case, the nondetect value was reduced to the greatest detected concentration in other samples taken from the well.

- Value was a detect that was much greater (generally more than 10×'s greater) than the next greatest detected concentration and appeared to be related to sample turbidity. In this case, the value was reduced to the next greatest detected concentration.

- Data point was for a filtered sample and was qualified "Q". In the data set used to derive the background concentrations, data points were "Q" qualified when analyses on a filtered sample were not performed because the results of the analyses of the total (unfiltered) sample were below the total sample's practical quantitation limit. In this case, the "Q" qualified data were modified by assigning to the data point the minimum detection limit of all samples taken from the well, or if there were no other nondetect results for the well, the minimum detection limit across all wells. This was done to ensure that the information such "nondetects" carry was included in the derivation of the background values.

For radionuclides, background concentrations were derived for total samples only because there were too few results from filtered samples. As with the summarization of the data for inorganic chemicals, some data were corrected during this activity. Reasons for correction of data for radionuclides were similar to those for inorganic chemicals.

Background concentrations for naturally occurring inorganic chemicals and selected radionuclides when data are summarized over all observations within group and summarized over wells within group are presented in Tables ES-1 and ES-2, respectively. In each of these tables, the background concentrations for inorganic chemicals in total and filtered samples and for radionuclides in total samples are listed by groundwater source. Also, human health risk-based concentrations (RBCs) based on residential use of groundwater and maximum contaminant limits (MCLs) are presented in each table.

Table ES-1. Background concentrations in total and filtered samples taken from the Regional Gravel Aquifer and McNairy Formation derived over all observations, residential use risk-based concentrations, and maximum contaminant levels

Analyte	Regional Gravel Aquifer		McNairy Formation		Risk-based Concentration[a]	Maximum Contaminant Level[q]
	Total Samples	Filtered Samples	Total Samples	Filtered Samples		
			Inorganic Chemicals (mg/L)			
Aluminum	2.189	0.311	0.687	0.579	1.5[HI]	0.050 - 0.200[k]
Antimony	0.060[b]	0.060[b]	0.060[b]	0.060[b]	0.00056[HI]	0.006
Arsenic	0.005[b]	0.005[b]	0.005[b]	0.005[b]	0.000035[CR]	0.050
Barium	0.235	0.200	0.296	0.268	0.10[HI]	2.000
Beryllium	0.004[b]	0.004[b]	0.017[b]	0.004[b]	0.000010[CR]	0.004
Cadmium	0.010[b]	0.010[b]	0.010[b]	0.010[b]	0.00066[HI]	0.005
Calcium	41.238	38.166	38.858	38.829	No Value	No Value
Chloride	91.021	No Data	19.708	No Data	No Value	250.000[k]
Chromium[d]	0.144	0.050[b]	0.060[b]	0.050[b]	0.0071[HI]	0.100
Cobalt	0.045[b]	0.045[b]	0.096	0.045[b]	0.091[HI]	No Value
Copper	0.036	0.020	0.057	0.013[b]	0.060[HI]	1.300
Fluoride	0.270	No Data	0.330	No Data	0.091[HI]	4.000
Iron	5.030	0.267	18.360	12.372	0.45[HI]	0.300[k]
Lead	0.129[c]	0.098[c]	0.050[b]	0.050[b]	0.00000015[HI]	0.015
Magnesium	16.262	16.215	13.418	14.171	No Value	No Value
Manganese	0.119	0.068	0.941	0.894	0.067[HI]	0.050[k]
Mercury	0.0002[b]	0.0002[e]	0.0002	0.0002[e]	0.00044[HI]	0.002
Molybdenum	0.050[b]	0.050[b]	0.050[b]	0.050[b]	0.0075[HI]	No Value
Nickel	0.682	0.305	0.109[b]	0.050[b]	0.030[HI]	0.100[o]
Nitrate as Nitrogen	15.561	No Data	1.474	No Data	2.40[HI]	10.000
Potassium	5.195	4.096	55.752	51.205	No Value	No Value
Selenium	0.005[b]	0.005[e]	0.005[b]	0.005[e]	0.0075[HI]	0.050
Silica	26.401	No Data	26.0	No Data	No Value	No Value
Silver	0.011[b]	0.060[b]	0.050[b]	0.050[b]	0.0075[HI]	0.100[k]
Sodium	59.450	60.433	29.2	27.98	No Value	No Value
Sulfate	19.947	No Data	28.9	No Data	No Value	500.000[h]
Thallium	0.056[b]	0.056[b]	0.644	0.056[b]	No Value	0.002
Uranium	0.002[b]	0.002[e]	0.001	0.001[e]	0.0045[HI]	0.020[h]
Vanadium	0.134	0.134	0.126	0.126	0.0092[HI]	No Value
Zinc	0.054	0.049	0.142	0.116	0.45[HI]	5.000[k]
			Radionuclides (pCi/L)			
Gross Alpha	5.8	No Data	11.9	No Data	No Value	15[h]
Gross Beta	13.8	No Data	144.5	No Data	No Value	i
Neptunium-237[l]	0.8	No Data	0.5	No Data	0.13[CR]	i
Plutonium-239	0.1	No Data	0.2	No Data	0.12[CR]	i
Radium-226[m]	0.6	No Data	1.2	No Data	0.13[CR]	5[p]
Radon-222[n]	626	No Data	295	No Data	1.4[CR]	300[h]
Technetium-99	22.3	No Data	20.6	No Data	28.0[CR]	i
Thorium-230	1.1	No Data	1.5	No Data	1.0[CR]	i
Total Radium[f]	1.3	No Data	0.7	No Data	0.13[CR]	5[p]
Uranium-234[g]	0.7	0.33	0.3	No Data	0.87[CR]	j
Uranium-235[g]	0.3	0.015	0.2	No Data	0.82[CR]	j
Uranium-238[g]	0.7	0.35	0.3	No Data	0.62[CR]	j

Notes:

No Data indicates that a background concentration could not be derived because data were inadequate or not available.

No Value under "Risk-based Concentration" indicates that a value could not be derived because the analyte lacks toxicity values. No Value under "Maximum Contaminant Level" indicates that neither a primary nor a secondary maximum contaminant level was available.

Table ES-1. (continued)

[a] All risk-based concentrations (RBCs) were derived using methods presented in Appendix 2 of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1506&D1, as modified by comments from regulatory agencies). In each case, the value reported is the lesser of the RBCs based on child systemic toxicity (HI) and lifetime cancer risk (CR). For HI, all values are based on a target of 0.1. For CR, all values are based on a target of 1×10^{-6}.

[b] This analyte was not detected in any sample used in the background calculations or infrequently detected at concentrations similar to their detection limit. Therefore, the reported "background concentration" is the minimum detection limit used for the analyte. If lower detection limits are used in future sampling and analytical efforts, then the background concentration for this analyte should be reevaluated.

[c] The calculated 95% Upper Tolerance Limit (95% UTL) for this analyte exceeded the analyte's maximum detected value. Therefore, the background concentration selected for the analyte was the analyte's maximum detected value.

[d] Background values are for total chromium. Risk-based concentration is for Chromium VI.

[e] All data for this analyte were "Q" qualified. The definition of this qualifier is, "No result available or not required because total analyses is less than PQL ." Therefore, the reported "background concentration" is the minimum detection limit used for the total analyses. If lower detection limits are used in future sampling and analytical efforts, then the background concentration for this analyte should be reevaluated.

[f] The risk-based concentration for Total Radium is that for radium-226 (+D). That value is the smallest of all those for radium isotopes.

[g] Background values for uranium isotopes were calculated from the uranium metal background concentration because data for individual isotopes was lacking. In this calculation, the natural abundance, by weight, (i.e., 0.0056% U-234, 0.72% U-235, and 99.27% U-238) and the specific activities (i.e., 6.21×10^{6} pCi/mg U-234, 2.15×10^{3} pCi/mg U-235, and 3.35 pCi/mg U-238) of the uranium isotopes were used. The RBCs for Uranium-235 and Uranium-238 were calculated using the cancer slope factors for Uranium-235+D and Uranium-238+D, respectively.

[h] Proposed value.

[i] If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or any organ is not to exceed 4 mrem/year.

[j] Proposed MCL for natural uranium (0.020 mg/L) is approximately equal to 30 pCi/L. This value applies to the sum of all isotopes.

[k] Secondary MCL.

[l] Risk-based concentration calculated using cancer slope factors for Neptunium+D.

[m] Risk-based concentration calculated using cancer slope factors for Radium-226+D.

[n] Risk-based concentration calculated using cancer slope factors for Radon-222+D.

[o] The EPA has deleted from the CFR both the MCL and the MCLG for nickel which have been vacated by court ruling, effective February 23, 1995 (60 FR 33926, June 29, 1995).

[p] The MCLs listed here for Radium-226 and Total Radium actually apply to combined Radium-226 and Radium-228.

[q] Federal and state MCLs were taken from the "Federal and State Guidelines" page found at the "Risk Assessment Information System" site at http://risk.lsd.ornl.gov/cgi-bin/guide/GUID_9709.

Table ES-2. Background concentrations in total and filtered samples taken from the Regional Gravel Aquifer and McNairy Formation derived over averages within wells, residential use risk-based concentrations, and maximum contaminant levels

Analyte	Regional Gravel Aquifer		McNairy Formation			Maximum Contaminant Level[q]
	Total Samples	Filtered Samples	Total Samples	Filtered Samples	Risk-based Concentration[a]	
			Inorganic Chemicals (mg/L)			
Aluminum	1.64	0.201	0.75	0.587	1.5HI	0.050 - 0.200k
Antimony	0.060[b]	0.060[b]	0.060[b]	0.060[b]	0.00056[HI]	0.006
Arsenic	0.005[b]	0.005[b]	0.005[b]	0.005[b]	0.000035[CR]	0.050
Barium	0.202	0.179	0.265	0.266	0.10[HI]	2.000
Beryllium	0.004[b]	0.004[b]	0.017[b]	0.004[b]	0.000010[CR]	0.004
Cadmium	0.010[b]	0.010[b]	0.010[b]	0.010[b]	0.00066[HI]	0.005
Calcium	40.0	35.8	39.47	40.27	No Value	No Value
Chloride	89.2	No Data	20.23	No Data	No Value	250.000[k]
Chromium[d]	0.134	0.050[b]	0.060[b]	0.050[b]	0.0071[HI]	0.100
Cobalt	0.045[b]	0.045[b]	0.072	0.045[b]	0.091[HI]	No Value
Copper	0.034	0.018	0.033	0.013[b]	0.060[HI]	1.300
Fluoride	0.245	No Data	0.298	No Data	0.091[HI]	4.000
Iron	3.72	0.164	15.83	9.446	0.45[HI]	0.300[k]
Lead	0.250	0.250	0.050[b]	0.050[b]	0.00000015[HI]	0.015
Magnesium	15.7	15.4	16.457	16.533	No Value	No Value
Manganese	0.082	0.048	0.729	0.682	0.067[HI]	0.050[k]
Mercury	0.0002[b]	0.0002[e]	0.0002[b]	0.0002[e]	0.00044[HI]	0.002
Molybdenum	0.050[b]	0.050[b]	0.050[b]	0.050[b]	0.0075[HI]	No Value
Nickel	0.682	0.305	0.109[b]	0.050[b]	0.030[HI]	0.100[o]
Nitrate as Nitrogen	13.5	No Data	1.43	No Data	2.40[HI]	10.000
Potassium	4.47	3.70	64.080	58.750	No Value	No Value
Selenium	0.005[b]	0.005[e]	0.005[b]	0.005[e]	0.0075[HI]	0.050
Silica	21.1	No Data	29.4	No Data	No Value	No Value
Silver	0.011[b]	0.060[b]	0.050[b]	0.050[b]	0.0075[HI]	0.100[k]
Sodium	63.5	65.7	24.92	25.90	No Value	No Value
Sulfate	19.1	No Data	27.27	No Data	No Value	500.000[h]
Thallium	0.056[b]	0.056[b]	0.255	0.056[b]	No Value	0.002
Uranium	0.002[b]	0.002[e]	0.001[b]	0.001	0.0045[HI]	0.020[h]
Vanadium	0.139	0.131	0.119	0.107	0.0092[HI]	No Value
Zinc	0.025	0.026	0.104	0.080	0.45[HI]	5.000[k]
			Radionuclides (pCi/L)			
Gross Alpha	2.36	No Data	5.3	No Data	No Value	15[h]
Gross Beta	7.3	No Data	125.4	No Data	No Value	i
Neptunium-237[l]	0.21	No Data	0.13	No Data	0.13[CR]	i
Plutonium-239	0.03	No Data	0.04	No Data	0.12[CR]	i
Radium-226[m]	0.10	No Data	0.29	No Data	0.13[CR]	5[p]
Radon-222[n]	555.3	No Data	228.3	No Data	1.4[CR]	300[h]
Technetium-99	10.8	No Data	7.8	No Data	28.0[CR]	i
Thorium-230	0.54	No Data	0.40	No Data	1.0[CR]	i
Total Radium[f]	0.46	No Data	0.36	No Data	0.13[CR]	5[p]
Uranium-234[g]	0.7	0.33	0.3	No Data	0.87[CR]	j
Uranium-235[g]	0.3	0.015	0.2	No Data	0.82[CR]	j
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Notes:

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[h] Proposed value.

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[j] Proposed MCL for natural uranium (0.020 mg/L) is approximately equal to 30 pCi/L. This value applies to the sum of all isotopes.

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[l] Risk-based concentration calculated using cancer slope factors for Neptunium+D.

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[q] Federal and state MCLs were taken from the "Federal and State Guidelines" page found at the "Risk Assessment Information System" site at http://risk.lsd.ornl.gov/cgi-bin/guide/GUID_9709.